Internal Reflection Sensor for the Cone Penetrometer

EIC Laboratories, Inc.

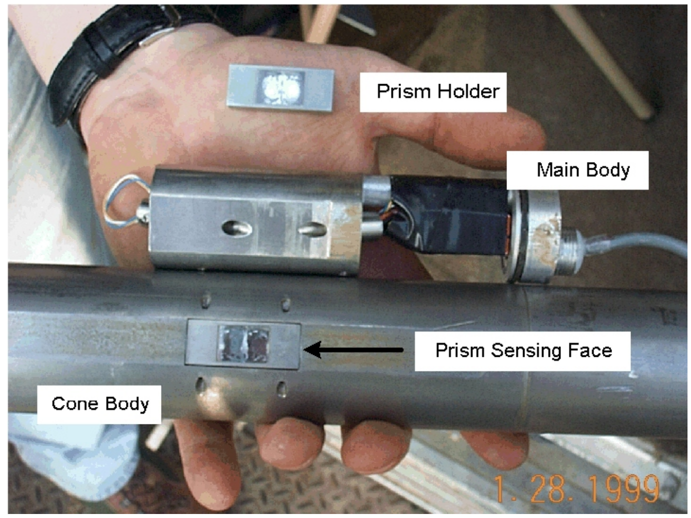
Technology Need:

Non-aqueous phase liquids (NAPLs) are environmental contaminants of particular concern because of the long-term threat they pose to drinking water supplies. NAPLs such as trichloroethylene, perchloroethyene and gasoline have low water solubilities and therefore, as "free phase" contaminant sources, are depleted only very slowly by dissolution into large volumes of groundwater. The result is widespread pollution that can continue for many years if the NAPLs are not located and removed. Locating NAPLs is a challenging task because they migrate through cracks and fissures in the subsurface soil to form small, isolated "pools" of contamination. A technology is needed for real-time detection of NAPLs, during site characterization.

Technology Description:

EIC Laboratories, Inc. has developed a rugged, inexpensive sensor that can be deployed in a cone penetrometer (CPT), for real-time , in situ detection of NAPLs, during site characterization.

The heart of EIC's Internal Reflection Sensor (IRS) is the internal reflection element. This element is positioned in the wall of the penetrometer cone so that its sensing face is in contact with the soil or groundwater as the cone is pushed into the ground. When NAPL is not present at the sensing face, laser light is fully reflected within the element and is detected in the sensor head. However, when NAPLs come into contact with the sensing face, the internally reflected light is diminished. This results in a decrease in the signal output by the detector: a positive indication of NAPL presence. Because the response from the detector is continuously measured at the surface by a voltmeter or computer, NAPLs can be detected instantaneously.



Components of IRS Module.

The IRS probe has the ability to detect both Dense-NAPLS (DNAPLs) and Light-NAPLs (LNAPLs). An important feature of the device is that it responds only to NAPL contaminants, without interference from dissolved-phase chemicals, natural soil components, or groundwater. The sensor operates in both the vadose and saturated zones.

Benefits:

- Provides real-time, in situ, continuous NAPL detection
- Meets sensing need for which no technology currently exists
- Improves the quality and reduces the time and cost of site characterization
- Minimum disturbance to the subsurface, as no drilling fluids are used and the hole diameters are small (less than 2-inches); this also minimizes migration of contaminants from shallower to deeper horizons during pushes

▸Decreased investigation derived waste (IDW): there are no drill cuttings

▸In situ analysis minimizes the human exposure to hazardous contaminants

▸CPT is less expensive than conventional rotary and auger drilling

▸CPT is faster than split-spoon sampling using conventional drilling techniques

Status and Accomplishments:

Development of the IRS probe was completed in May 1999. The IRS was field-tested twice using the Department of Energy's (DOE's) cone penetrometer truck; at the Savannah River Site (SRS) in Aiken, SC and at Sage Dry Cleaners, a former commercial site, in Jacksonville, Florida. Both sites are known to have subsurface DNAPL contamination. The objective of the demonstrations was to utilize the CPT-deployed IRS probe to positively identify the presence of DNAPL in the subsurface, and in real time. To verify the results of the IRS probe, a CPT Raman sensor was co-deployed with the IRS probe. Validation of the results at the Sage site was based on information from previous site investigations.

The first demonstration of the IRS was conducted at the SRS M-Area Seepage Basin using the DOE cone penetrometer truck in 1998. The basin has a history as the disposal site of several million kilograms of waste solvents in the 1950s. These solvents, primarily PCE and TCE, were used in vapor degreasing operations. This site is well characterized with respect to both geology and extent of contamination. The subsurface geology is primarily sand and clay. Two successful pushes were completed to depths greater than 100 ft.

The second demonstration of the IRS was performed at a commercial site in Jacksonville, Florida. This site, known as Sage Dry Cleaners, was once a commercial dry cleaning site and later used as a gas station. The site is well characterized and identified to be heavily contaminated with PCE. The subsurface geology is primarily sand. The demonstration at the Sage Dry Cleaners consisted of two pushes in one day and was accomplished in cooperation with ARA, the operator of the DOE cone penetrometer truck.

The results from these demonstrations of the IRS provided valuable information about the capabilities and shortcomings of the prototype sensor. The IRS responded positively to the presence of DNAPL in a manner that could be utilized to detect DNAPLs. Though the IRS responded positively to the presence of DNAPL, extraneous responses were also observed that complicated the interpretation of results. The extraneous responses were attributed to flexure of the sensor resulting in a decrease in reflected light. In some cases it is difficult to definitively determine whether the probe is responding positively to DNAPL or responding falsely due to flexing of the sensor. The problem related to the probe flexing under stress should be correctable by design modifications to give the sensor additional strength and rigidity.

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Online Resources:

Office of Science and Technology, Technology Management System (TMS), Tech ID # 1723
http://ost.em.doe.gov/tms

The National Energy Technology Laboratory Internet address is http://www.netl.doe.gov

For additional information, please visit EIC's website at http://www.eiclabs.com/

An Innovative Technology Summary Report (ITSR) is available for this technology at
http://apps.em.doe.gov/ost/pubs/itsrs/itsr1723.pdf